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Catalytic converter arrangement for reducing nitrogen oxides

In a catalytic converter arrangement for reducing nitrogen oxides in exhaust, this takes place over a broad temperature range. In order, within this temperature range, to achieve a sufficient denitrogenating performance and adaptability to the respective exhaust temperature range, at least two catalyser beds (7, 8) made of different catalyser materials are arranged one after the other in the flow direction of the exhaust gas for reducing nitrogen oxides. The different catalyser materials have their strongest catalytic effect in different, adjacent regions of the exhaust gas temperature range.

Description

The invention concerns a catalyser arrangement for reducing nitrogen oxides in exhaust gas occurring in a broad temperature range.

In internal combustion engines used for electrical generating, the rotary speed is usually constant, so that the exhaust flow rate hardly changes. Depending upon the loading of an engine, however, the exhaust temperature changes and thus also the NO_2 content. The exhaust temperature range lies, for instance, between 290°C and 460°C.

In the journal "Staub Reinhalting der Luft" [Dust Prevention in the Air] 49 (1989), pages 37 to 43, various catalyst materials are described which may be used at higher exhaust temperatures or at lower exhaust temperatures.

Further catalyst materials are described in DE 35 05 648 C2 and in EP 01 68 811 B1.

In the prior art, it is assumed that, in each case, a single catalyst material is used for the catalyser, which covers the exhaust temperature range. In practice this is difficult to realise.

It is the aim of the invention to propose a catalyser arrangement of the aforementioned type which has an adequate denitrogenating performance over a wide exhaust temperature range and is adaptable to the respective exhaust temperature range.

According to the invention, the above aim is fulfilled in that at least two catalyser beds for reducing nitrogen oxides and made of different catalyser materials are arranged one after the other in the flow direction of the exhaust gas, and that the different catalyser materials have their strongest catalytic effect in different, adjacent regions of the exhaust temperature range.

In that at least two different catalyser materials lie within the exhaust stream, these may be selected with regard to an optimal effect in a partial region of the exhaust temperature range of the engine. The catalyser arrangement may therefore be adapted in simple manner to the characteristics of the exhaust stream of the respective engine. If a larger quantity of nitrogen oxides must be reduced at higher temperatures than at lower exhaust temperatures, then the catalyser bed that is effective primarily at higher temperatures may be designed accordingly.

Overall, the necessary denitrogenating performance throughout the entire exhaust temperature range may be assured without a single catalyser material specially designed for the respective temperature range being provided for this. It may suffice to provide two catalyser beds, of which one is effective at low temperatures and the other at high temperatures of the exhaust gas range. Further catalyser beds may, however, also be provided for medium temperature ranges with appropriately selected catalyser materials.

Advantageous designs of the invention are disclosed in the subclaims and the following description of an example. The drawings show the following:

Fig. 1 a catalyser arrangement in section and

Fig. 2 an exhaust gas/temperature diagram.

A catalytic converter arrangement has an inlet 1 for an exhaust gas stream from an internal combustion engine. In a housing 2, arranged one after the other in the flow direction of the exhaust gases are a soot particle filter 3, a temperature peak buffer 4, an injection device 5 for ammonia, a flow mixer 6, a first denox catalyser bed 7, a second denox catalyser bed 8 and an oxidation catalyser bed 9. Last of all, there is an outlet 10.

The soot particle filter 3 filters soot particles out of the exhaust gas. During combustion of the deposited soot

particles, temperature peaks occur. These are smoothed out in the temperature peak buffer 4, so that the subsequent components do not become damaged.

In the filtered exhaust stream, ammonia is injected in distributed fashion by means of the injection device 5. The exhaust stream laden with ammonia is directed and homogenised in the flow mixer 6.

The first catalyser bed 7 contains a catalyser material whose optimum effectiveness lies in a higher temperature region than the catalyser material of the second catalyser bed 8. The catalyser material of the first catalyser bed 7 is built up, for instance, on the basis of iron sulphate $Fe_2(SO4)_3$ or a molecular sieve (zeolith). The catalyser material of the second catalyser bed 8 works, for instance, with a mixture of titanium oxide (TiO_2) and vanadium pentoxide (V_2O_5) or a mixture of iron oxide (Fe_2O_3) and chromium oxide (Cr_2O_3).

In Fig. 2, a dashed line represents, for one application case, the NOx loading of the exhaust gas at the inlet 1 against operating temperature. It has been assumed that in this case, the exhaust temperature lies approximately between 290°C and 460°C. The NOx loading of the exhaust gas stream rises almost linearly between a temperature of 300°C to a temperature of 450°C from 1000 ppm to over 2000 ppm.

The dot-dashed line in Fig. 2 shows the temperature-dependent effect of the catalyser material of the first catalyser bed 7. The effect of this catalyser material in the low temperature range between 300°C and 400°C is clearly lower than in the range between 400°C and 460°C. The dotted line in Fig. 2 shows the catalytic effect of the catalyser material of the second catalyser bed 8. Clearly, its effect declines above about 400°C.

The solid line in Fig. 2 shows the NOx content of the exhaust gas on the outlet side across the exhaust gas

temperature range. Up to about 430°C, the NOx content at the outlet is below 100 ppm. Thereafter, it increases until about 460°C to a little over 100 ppm, but without reaching 200 ppm.

At relatively low temperatures up to about 400°C, NOx in the exhaust gas is only converted a little in the catalyser bed 7. The major part of the conversion occurs in the catalyser bed 8 according to the formula:

$$4NO + 4NH_3 + O_2 \rightarrow 4N_2 + 6H_2O$$

At relatively high temperatures, the conversion also takes place according to the above equation, but mainly not in the catalyser bed 8, rather, overwhelmingly in the catalyser bed 7. In the catalyser bed 8, only the quantities of NH_3 and NOx not converted in the catalyser bed 7 are further reacted.

In the oxidation catalyser bed 9, hydrocarbons are oxidised and CO is converted to CO_2.

Claims

1. Catalyser arrangement for reducing nitrogen oxides in exhaust gas occurring in a broad temperature range, characterised in that at least two catalyser beds (7,8) made of different catalyser materials for reducing nitrogen oxides are arranged one after the other in the flow direction of the exhaust gas, and that the different catalyser materials have their strongest catalytic effect in different, adjacent regions of the exhaust temperature range.

2. Catalyser arrangement according to Claim 1, characterised in that an ammonia infeed is arranged before the catalyser bed (7) frontmost in the flow direction of the exhaust gas.

3. Catalyser arrangement according to Claim 1 or 2, characterised in that the catalyser bed (7) whose optimum effect lies in a higher temperature region, is arranged before the other catalyser bed (8) in the flow direction.

4. Catalyser arrangement according to one of the previous claims, characterised in that the catalyser material for the higher temperature region is based on iron sulphate.

5. Catalyser arrangement according to one of the previous claims, characterised in that the catalyser material for the lower temperature region is based on a mixture of titanium oxide and vanadium pentoxide or iron oxide and chromium oxide.

6. Catalyser arrangement according to one of the previous claims, characterised in that the catalyser bed (7) frontmost in the flow direction has connected before it a soot particle filter (3) with a temperature peak buffer (4).

7. Catalyser arrangement according to one of the previous claims, characterised in that an oxidation catalyser bed (9) is connected after the catalyser bed (8) hindmost in the flow direction.

[Fig. 2, labels on graph:]

NOx at outlet, ppm

NOx at inlet, ppm

NOx - inlet

HT catalyser

Combination HT + LT

LT catalyser

Temperature, °C